

## **Evaluation of Efficacy of Microbial Biological Control Agents - Commercially Acceptable Control Levels**

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Disease control efficacy and consistency have been major stumbling blocks to the wide-spread acceptance and use of biological control (BC) of plant diseases. Flawless laboratory experiments often underperform when transferred to natural crop production settings where microbial biocontrol agents (MBCAs) encounter more variable environmental and biological conditions. Various approaches have been developed to counteract these shortcomings, and in many instances the robustness of BC systems has been improved to the point that an increasing number of MBCAs have been commercialized; with many more ready for commercial use pending their registration. The slow and costly registration process delays, and often prohibits, registration of MBCAs. Despite their very different nature, MBCAs are under the same regulatory constraints as chemical pesticides. Removing MBCAs from the chemical paradigm could facilitate faster and cheaper registration of BC products, and ultimately greater use of BC. This is because the cost, efficacy, and use of BC agents are linked. The cost of development and production of MBCAs is passed to the grower in form of the high price of the BC product. In order to use the BC product, the grower must pass this cost, and the offset of possible reduced efficacy (as compared to chemical pesticides), to the consumer. The factors affecting the grower's decision to use MBCAs include the availability of alternative control strategies, the efficacy and consistency of BC, the production system (conventional, organic, integrated), market potential, and word of mouth about the usefulness of the BC treatment. If the consumer is willing to pay higher prices for pesticide-free produce, then grower demand for the BC product will continue, and the product will succeed on the market. Consumer concerns over chemical pesticide residues have been the main incentive for purchasing pesticide-free produce, which often carry a hefty price tag. A recent survey in Europe showed that perceived negative effects of pesticide residues were a major concern to 71% of the respondents in the European Union; 86% in Italy, 55% in Belgium, and 47% in The Netherlands. Other reasons for purchasing organic produce (which can be treated with BC) are the better organoleptic and nutritional qualities, and the reduced impact of organic crop production on the environment. Although the latter may be a tough sell to the consumer, there is a significant segment of society genuinely concerned with the environmental impact of chemical pesticides.

The acceptable efficacy of BC products is dependent on many factors including availability of the alternative control measures, value of the crop (field crops, nursery crops, orchards, postharvest, etc.), production system, ability to combine the BC product with other non-chemical

alternatives, return on investment, governmental regulations (e.g. efficacy data requirements in California, IR-4, EU, restriction on use of pesticides), and involvement of the government in running BC programs.

The efficacy of BC products is often compared to chemical controls. However, it may be inappropriate to equate BC with chemical treatments without considering a full accounting of advantages and limitations of both approaches. This comparison is unfortunate because the added value of BC, e.g. high value organic produce, reduction in development of resistance to chemicals by pathogens (e.g. streptomycin for fireblight), control of pesticide-resistant pathogens, or control of both plant and foodborne pathogens at the same time, is seldom taken into account. In addition, the added value of the reduced negative impact on human health and the environment is difficult, if not impossible to quantify.

Commercially acceptable BC levels vary with the crop and production system, e.g. for fireblight control it is substitution of 50% of the streptomycin sprays with Blightban A506 sprays without increasing number of fireblight strikes per tree; for Afla-gard it is any reduction in aflatoxin in peanuts or corn – preferably to less than 20 ppb (limit in food set by the FDA); for peach tree short life it is control of nematodes for 2-3 years after pre-plant application and extension of peach tree life to 15 + years; for take-all decline it is achieving approximately 90% of the wheat yield of unaffected fields; for the apple replant problem it is a fruit yield equivalent to fumigated plots; for damping-off of cucumbers it is an increase in seedling stand to the level of the uninoculated control; and for postharvest decays of pome, stone and citrus fruits, it is consistently keeping decay below 2% for conventional production and a reduction of natural decay levels by half (to 1.5 - 4.5%) for organic fruit.

Biological control has limitations with regard to the spectrum of activity and levels of control. However, many of these limitations can be addressed by improving the robustness and efficacy to fit individual BC systems. This can be accomplished, for example, by using locally adopted antagonist strains, enhancing BC performance by combining antagonists or adding nutrients that stimulate antagonist growth and/or mechanisms of BC, combining BC with other alternatives to chemical control treatments, more tests under commercial conditions, and improving formulation and quality control of BC products. The beauty of BC, among many other things, lays in its amenability to manipulation, which provides almost endless opportunities for improving the system. As the acceptable level of performance may vary with different BC systems, the overarching measure of acceptable BC performance is the price that the market is willing to tolerate. Consequently, reducing the cost of development, production, and implementation of MBCAs remains the major challenge for the greater use of the biological control.